THE STATE OF VIRTUAL REALITY IN EDUCATION 2020

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ABSTRACT
In 2018, the authors published an article entitled, “The State of Virtual Reality in Education”. This paper outlined the background and then current state of virtual reality (VR) in the education field, and categorized VR technology into three tiers: High-end, mobile, and mass-distributed. Since then, VR has further matured as a technology, blurring the lines of the aforementioned categories, and expanding upon its possible applications for education. Researchers have continued to discover new ways to apply this medium in the classroom and for remote learning. This paper will briefly explore how VR technology has continued to develop, examining the practical effects this has had on its applicability in classroom settings. The authors will then summarize the ways VR has been used in education to support experiential learning and investigate the latest innovative practices. Finally, they will outline some considerations that should be taken into account before implementing VR in classrooms. This paper should serve as an entry point for educators looking to implement new instructional mediums into the learning process.

Introduction

Virtual reality (VR) in the past has been defined as any 3D experience where users control an avatar in a virtual 3D space. However, since such experiences are now prolific and on everything from laptops to game consoles to mobile phones, it has become necessary to differentiate VR from any 3D game-like experience. Since the release of dedicated VR headsets in the 2010s, VR would be better defined as replacing a person's physical environment with a virtual one via a head-mounted display. Since the release of these modern VR headsets in many different forms since 2013, VR has sufficiently matured as a new medium of immersive entertainment and education. The educational affordances of VR have enabled both research and practice in independent classrooms and research institutions across the world. In recent years, it is easy to find both informal education blogs and research articles looking into the uses of VR in the classroom.

From its earliest incarnation in the late 1960s as a technology only accessible to the largest of educational research institutions, to its current manifestation as an ever increasingly accessible technology for use in any classroom, VR as an educational tool continues to evolve. Educators who may have dismissed it only a few years ago, would do well to reevaluate their perceptions of the technology and assess its suitability as a tool for education in their context. With this in mind, the authors of this paper seek to provide an updated overview of VR in light of the technology's developments since the publication of their previous investigation into the affordances of VR for education, "The State of Virtual Reality in Education" (Lege & Bonner, 2018), written in late 2017.

Recent advancements in VR hardware

The State of Virtual Reality in Education discussed the then current state of VR and detailed its suitability for use in classrooms as a result of the immersion and presence that VR headsets of the time afforded. It also categorized VR into three tiers, depending on the level of immersion possible for each type of VR headset. These tiers were:

- High-end: Full-body motion tracking headsets tethered by cables to powerful computers, capable of simulating complex, interactable and realistic environments.
- Mobile: Untethered headsets powered by premium smartphones, limited to simulating head rotation and simple motion gestures, best suited for simple 3D applications.
- Mass-distributed: Untethered cardboard headsets powered by any smartphone, limited to head rotation only, so best suited for consuming 360-degree videos.

Since then, VR headsets have continued to improve and evolve, resulting in these tiers no longer accurately representing the division of VR's immersive capabilities. In the years

since the original paper on the state of VR, the ecosystem of devices centered around what the authors referred to as the mobile tier has undergone some major changes. Major tech companies have discontinued their mobile VR platforms: First, in August 2019 Samsung announced their upcoming new smartphones would not support the *Gear VR* headset (Peters, 2019), then in October of the same year *Google* quickly followed by announcing that no future *Android* smartphones would support their *Google Daydream View* headset. *Google* gave the rationale that "there hasn't been the broad consumer or developer adoption we had hoped, and we've seen decreasing usage over time of the *Daydream View* headset." They also stated that "asking people to put their phone in a headset and lose access to the apps they use throughout the day causes immense friction" (Roettgers, 2019). These sentiments were echoed by John Carmack, the Chief Technology Officer for *Oculus* who designed *Samsung's Gear VR* headset (Hayden, 2019).

The mobile tier has since evolved into standalone VR headsets that incorporate the equivalent of premium smartphone hardware inside the device. These devices, such as the widely successful *Oculus Quest* released in 2019, are quickly becoming the most popular type of VR headset. Standalone VR headsets offer the same full body and hand motion tracking capabilities of the high-end tier, albeit with less graphically impressive visuals. These devices are only half the price of a common workplace laptop (*Oculus Quest* is priced at $399 USD as of 2020) and are thousands of dollars cheaper than an entire high-end tier setup. This makes standalone VR the most sensible solution for teachers looking to utilize highly immersive VR in their classrooms without all the cost and bother of a high-end tier setup. With high-end VR, the user must turn on the PC, boot into the operating system and turn on the VR software, then unravel the cables and set up the equipment before being able to actually put on the headset and start experiencing VR content. Standalone VR headsets such as the *Oculus Quest* have a sleep mode, meaning simply putting on the headset starts the VR experience. As a result of this, aside from the visual fidelity of high-end tier VR, most teachers have no need to consider it for classroom use. With all this in mind, the authors now propose amending their previous three tiers:

High-end VR: High-end VR no longer offers enough benefits beyond the standalone tier to be worth consideration by educators. The benefits of some exclusive applications and the most visually impressive experiences are off-set by the considerable cost, tethered cables, and the long setup times.

Standalone VR: This tier is arguably the future of VR in education due to its tetherless nature, immersive capabilities, wide range of applications, and relatively low price.

Mass-distributed VR: Most developers have stopped producing new content for mass-distributed VR headsets such as *Google Cardboard*. However, the amount of existing and new 360-degree videos that can be consumed by students means that educators should

not dismiss this tier. Teachers looking to get VR into the hands of all their students should still consider mass-distributed VR as a window into experiencing lesson content. They are also extremely cheap, and rely only on students having a smartphone.

State of VR software for education

While the technology itself has continued to advance and evolve, the number of commercial off-the-shelf (COTS) applications directly aimed at education remains limited, regardless of the tier. VR continues to grow as an entertainment medium but the currently small market for VR educational technologies means that developers are not likely to develop for this market (Kavanagh et al., 2017) until it reaches a level of mass consumer adoption. However, this does not mean that there is a lack of VR applications suitable for use in classrooms, as many COTS applications can be adapted for use in education. As an example, the authors have published a framework for adapting existing applications for use in second language acquisition that is recommended for any teacher looking to utilize VR within that context. Please refer to *Pedagogical Considerations for Successful Implementation of Virtual Reality in the Language Classroom* (Lege, Bonner, Frazier, & Pascucci, 2020).

Unattainable environments

VR is most successful when the educational activity leverages the unique immersive capabilities of the technology to fulfill an instructional need that cannot be satisfactorily met with other available methods. Hu-Au and Lee (2018) note that VR is perfect for schools seeking learning experiences, but unable to venture out into the field. For this purpose, educators have used VR to take students to inaccessible environments like the Arctic or deep ocean (Nicholson, 2018), and historical locations (Blazauskas, 2017). Mills (Virtual reality narratives, n.d.) employed VR to allow French students to visit Paris. Frazier and Roloff-Rothman (2019) took their global issues students virtually to refugee camps, American political rallies, and religious pilgrimages. VR can offer a window to another place and time, and can put students into places that were not accessible.

Engagement

Most VR studies to date contain some measure of motivation and engagement, and consistently report that its use leads to increased interest and engagement with the subject matter (see Costa & Melotti, 2012). In their study comparing a lesson delivered using a slideshow to a lesson using VR, Parong and Mayer (2018) found that students were “happier, more excited, and less bored” (p. 8). Other researchers and practitioners have similarly found that VR increases student motivation (see Tai, Chen, & Todd, 2020; Cho, 2018; Kaplan-Rakowski & Wojdynski, 2018; Velev, 2017).

Memory

VR has also been shown to be effective for certain educational applications involving memory. Pollard et. al (2020) found that participants were able to better recall and recognize objects from highly immersive VR experiences than less immersive conditions. Cho (2018) found that "Due to a sense of presence, if learners replicate language study in VR simulation, it can help them remember words more efficiently" (p. 59). Studies such as these seem to indicate that the cognitive processes connected with storing memories can be affected by the immersive nature of VR.

Empathy training

VR allows for users to be immersed in virtually any environment or situation, including recreations of the experiences of others. Because of this ability, VR has the capacity to foster empathy, and has even been called "the empathy machine" by media outlets (for example, see Constine, 2015). This important capability has not been overlooked by developers or educators. At the time of publishing, there are many well reviewed, high quality VR experiences designed to put users in the place of others, such as *Driving While Black, Notes on Blindness,* and *Anne Frank House VR*.

VR has been used to build empathy towards victims of sexism in math classes (Chang, et al., 2019), homelessness (Herrera, Bailenston, Weisz, Ogle, & Zak, 2018), and racism in the United States (Roswell et al., 2020). Potentially, VR could be used in this manner to allow students to embody others for access to a wide range of perspectives and experiences beyond their normal spheres of interaction.

Distance Learning

Urueta and Ogi (2020) evaluated distance learning conducted entirely in VR, concluding that "high-presence VR scenarios can be useful for task-based language acquisition, increasing student interest and confidence, and providing alternative immersive learning methods with a high level of student-teacher interaction" (p. 366). These perceived benefits should be applicable to any discipline, not only language learning, which are based on learning by holistic experiences.

Considerations for use in the classroom

Need for specific pedagogy

As VR has become more accessible for educators, researchers have pointed out the importance of developing programs and pedagogy that allow for VR to be used effectively. Elmqaddem (2019) points out that "it will be necessary to know how to build and deploy educational programs that are well adapted to this technology and that best meet the

requirements of the learner of the 21st century" (p. 237). Hu-Au and Lee (2018) echo this sentiment, calling for attention to VR pedagogy, noting that "a wrong way of implementing VR in education would be simply to replicate face-to-face, didactic experiences of learning" (223). This call for the development of a specific pedagogy for VR is a common thread in many works that are critical of VR in the classroom. Recent work, such as the authors' own framework for analysis and implementation of commercial off-the-shelf VR applications in the language classroom (Lege, Bonner, Frazier, & Pascucci, 2020) seeks to address this issue by providing a way to evaluate VR content for classroom pedagogical applications. In addition, Southgate's (2020) "Actioned Pedagogy for Immersive Learning (APIL)" (p. 31) guides educators through the process of considering the teacher realm, learner realm, and the technical realm to help them apply VR for learning in a pedagogically sound manner. Despite these recent additions to the body of literature, there is still a strong need for works supporting sound pedagogical application into educational practice, especially with regards to high-end and standalone VR, which offer the most affordances for immersive classroom activities.

Anxiety and self-consciousness

Teachers need to consider that some students may not be comfortable wearing the headset for a variety of reasons and should consider creating activities that incorporate non-VR roles. Students may express concerns about their personal space or feeling vulnerable or self-conscious while in VR as they are unable to see their classmates and what they are doing.

Safety

It's also important to remember that any activity taking place in an online environment that exposes students to strangers must take the usual precautions to avoid exposing students to harassment. In addition to verbal harassment, remember that personal space harassment is also a common issue online, so investigate the online application's anti-harassment features before conducting the activity.

Sanitation

Sanitation is also more important than ever. Teachers should, of course, use personal disposable face masks for each user, and if possible, endeavor to only allow one student to use a particular headset for the entire activity. It's also important to remember to clean each headset before and after use. As a side note, alcoholic wipes can damage the sensitive VR lenses, so additional care must be taken when cleaning VR equipment.

Conclusion

VR technology is in a constant state of flux and evolution, both in terms of the technical hardware itself and its application for teaching and learning. In this paper, the authors have sought to summarize the most recent and state-of-the-art publications as a way of encapsulating the current state of VR in education. The authors hope that this leads to informed research and classroom applications of VR that leverage the unique capabilities of the medium to innovate the frontiers of learning. To date, immersive VR has been both used and evaluated in education for a variety of purposes. Though still in its infancy, there is clear promise to this technology, coupled with unique considerations that need to be addressed.

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